A Description of the Plant Microfossils in an Eocene Clay, a Paleocene Shale, and a Carboniferous Coal.

by

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INTRODUCTION

Palynology is defined by Hyde and Williams (1944) as the study of pollen and spores and their dispersal and applications thereof (Tschudy and Scott, 1969). In general, the science of palynology includes both modern and fossil pollen and spores. This paper deals with some aspects of fossil pollen and spores recovered from three different facies representing different geologic periods.

As in other areas of paleontology, palynology includes several basic assumptions. The first of these is that the present is indicative of the past. In addition, it is assumed that fossils are evidence of a continuum of once-living organisms, whose succession is due to organic evolution. Like certain parts of animals, plant remains, especially pollen and spores, can be useful in biostratigraphy. They have been found in rocks ranging from the Precambrian to the Recent, and underscore numerous evolutionary trends.

Palynological specimans, or palynomorphs, make particulary good index fossils for several reasons. First, they have a general resistance to degradation due to the chemical nature of the wall. Second, they are small (most less than 200 microns) and therefore are easily distributed in a variety of sedimentary facies. Third, many are morphologically complex, and thus they can be readily distinguished. Fourth, pollen and spores are often produced in enormous numbers. This enables many palynomorphs to be recovered in statistically significant assembleges (Tschudy and Scott, 1969).

The intent of this paper is to describe the palynomorphs in three samples, each differing in geologic age and composition (a Carboniferous coal, a Paleocene shale, and an Eocene clay). Each sample yields a characteristic assemblege of fossils for that particular age, and thus demonstrates the stratigraphic value of fossil palynomorphs.

METHODS

All of the samples were subjected to the same initial treatment to release palynomorphs. The techniques used were adopted from "Palynomorph Preparation Procedures", a circular distributed by the United States Geological Survey, circulation number 830. Intially, samples were washed with soap and water to free the surface of any contaminants, such as pollen and spores currently in the air. Then, using a mortal and pestal, the matrices were pulverized. Half of each sample was set aside, in case the procedures required repeating; the other half was treated with a series of solutions to dissolve the mineral matter. Each sample was handled independantly. The following is a list of laboratory steps used.

HCl Acid

The samples were soaked in ten percent HCl acid long enough to dissolve any carbonaceous material.

HF Acid

The samples were soaked overnight in concentrated (47%) HF acid. This was done to dissolve siliceous components.

Optical Check

Each sample was examined microscopically to determine if they needed to be broken down further. If organic material did not appear to be free of the mineral matrix, the sample was oxidized. Based on this optical test, the Paleocene and the Eocene samples did not require oxidizing. The coal, on the other hand, was treated with Schulze's solution.

Schulze's Solution

Schulze's solution is a strong oxidizer and consists of two parts nitric acid (HNO_3) and one part potassium chloride ($KClO_3$). After the coal soaked in this solution ten to fifteen minutes, a drop of KOH was added to the sediment. If a reaction causing brown fumes resulted, oxidation was not complete. The coal was left in Schulze's solution until oxidation was complete; approximately fifteen minutes.

Zinc Bromide Flotation

Fifty grams of zinc bromide (density = 4.20) was mixed with 25.00 grams of water (density = 1.00) to make a solution of 2.00 density. When the sample was added to this zinc bromide solution, the lighter pollen and spores floated to the surface while the heavier minerial matter settled to the bottom. Once the sediment was put in the zinc bromide solution, it was allowed to separate into two distinct layers. After the material separated, the top layer was removed and used in the following steps. The heavier mineral material was discarded.

Acetolysis

The acetolysis mixture consists of nine parts acetic anhydride ($(CH_3CO)_2O$) and one part sulphuric acid (H_2SO_4). The sediment was added to this solution to dissolve any cellulosic plant material that was present. Also, the palynomorphs are darkened after being acetolized enabling them to be seen under a microscope. For this reason, half of each sample was acetolized and half was stained.

Staining

Samples were dehydrated beginning with 40%, 60%, 75%, and 95% ethanol (ETOH). The samples that were not acetolized were soaked for fifteen minutes in safranin stain. Finally, all the samples were washed in 100% xylene. They were stored in 100% xylene and later mounted on slides in Harleco Synthetic Resin mounting medium (HSR) for compound light microscopy.

OBSERVATIONS

Carboniferous Coal

Locality: The first sample is a Carboniferous coal taken from an exposure in a road cut approximately five miles west of Steubenville, Ohio. The coal at this locality is exposed as two seams separated by two to three feet of the Ames Limestone. the top seam is referred to as the Duquesne Coal and is 0-38 cm. thick. It is light brown-beige and contains extensive, well preserved plant remains. Also in the Duquesne Coal are isolated coal balls ranging in size from 3 cm. to one meter. The surrounding material is white-gray limestone. The lower coal seam is referred to as the Ames Coal, and it lies below the Ames Limestone. The thickness of this seam ranges from 20-76 cm.. It contains isolated coal balls as well as crushed plant parts (Rothwell, 1976).

Laboratory Observations: The coal reacted slowly to both HCl and HF acid maceration. After treatment with Schulze's solution, the material disassociated into heavy and light aggregates. The lighter material stayed in suspension even after centrifugation. Since the palynomorphs were more concentrated in the lighter material, the suspended portion was saved for the rest of the procedures. The supranate was poured off and left over night to settle. After maceration was complete, the sample still contained a fair amount of mineral aggregates. The presence of mineral matter made it difficult to recognize the palynomorphs under the microscope.

Descriptions of Palynomorphs:

Type 1 (Fig. 1) Similar to *Punctatisporites rudis*, but with no trilete mark (Peppers, 1964).

These grains are common in the coal sample. Eighteen out of 50 grains that were counted were of this type. These grains range in size from 20-76 um and have an irregular circular amb. The grains are rough looking due to the prominent surface elements which stand in considerable relief. The ornamentation pattern is rugulate. Many grains have a furrow-like opening seen along the outside margin. Also, along the margins of some grains are two conspicuous darkened areas that look like apertures. Fig. 1 shows a grain with two darkened areas and a furrow-like structure.

Type 2 (Fig.2) Similar to *Hamulatisporites amplus* (Elsik. 1968).

These grains are less common than type 1. Nine out of 50 grains counted were of this type. Perhaps a larger percentage existed than was observed since they were found only in the acetolized material. These grains appear opague under the microscope; thus ornamentation features are difficult to recognize. The outline of the grains are slightly irregular. Also along the margins, are one to three aperture-like structures that extend about 5 um along the amb and protrude about 1 um from the surface.

Type 3 (Fig. 3) Similar to _Lycospora_ (Schopf, Wilson and Bentall, 1944) but no trilete mark is evident.

Eight out of 50 grains that were counted were of this type. These grains are 42 um and are convex triangular. The ornamentation is psilate to faintly reticulate. Most grains have a slit along the outside margin, usually in the interradial areas. Fig. 3 shows two grains of this type in two different orientations.

Type 4 (Fig. 4 and 6) Resembles _Spheripollenites perinatus_ (Brenner, 1963).

Only five out of 50 grains were of this type. These grains are 20 um and have a circular amb. The ornamentation is psilate to faintly reticulate. The grains have a distinctive, thick outline which suggests a thick wall. Some grains have no apparent aperture (Fig. 4), while others have an obvious bud-like extension at one end (Fig. 6).

Type 5 (Fig. 5) Affinities unknown.

Two out of 50 grains counted were of this type. These are 25 um with an elliptical amb. They are psilate. The distinctive characteristic is the collapse feature which takes up over 50% of one face.

Type 6 (Fig. 7) Similar to _Granulatisporites convexus_ (Kosanke, 1950).

This type of grain is uncommon in the coal sample. Only 2 out of 50 grains were of this type. These are

30 um and subtriangular and convex. Ornamentation is reticulate. A few scattered pores that vary in size are seen on the surface of these grains.

Type 7 (Fig. 8 and 10) Similar to Valvisisporites (Pigg and Rothwell, 1983).

Five out of 50 grains found are of this type. Grains are about 60 um and are psilate. Fig. 8 and Fig. 10 may be two orientations of the same kind of grain. Fig. 8 is a lateral veiw and fig. 10 is a distal or proximal view. These are heteropolar grains, one pole comes to a peak and has an aperture-like opening. The other pole is rounded off and boat shaped. The equatorial area is slightly thickened.

Type 8 (Fig. 9) Similar to Calamospora pedata (Kosanke, 1950).

Only one out of 50 grains were of this type. It is elliptical (35 x 60 um) and psilate with a thin wall. One end of the grain has a small notch or fold.

Fig. 1

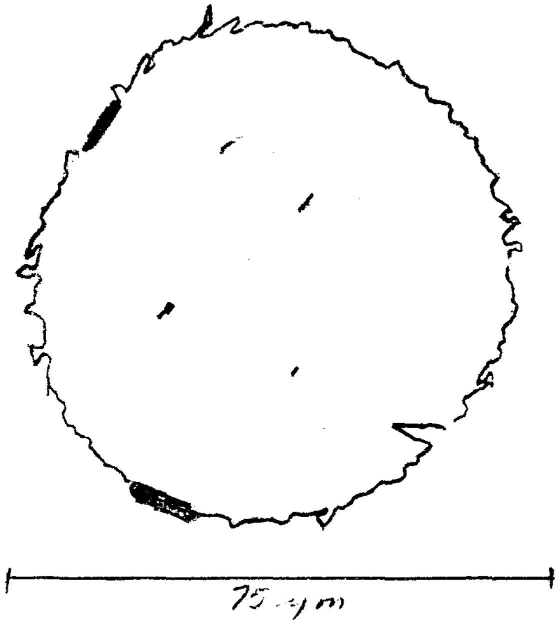


Fig. 2

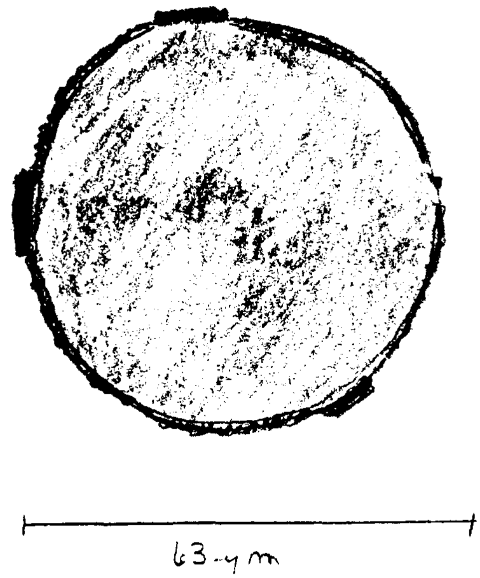


Fig. 3

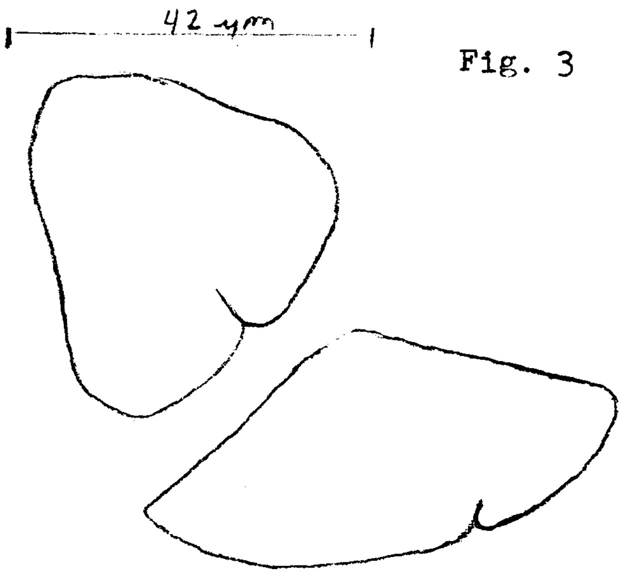


Fig. 4

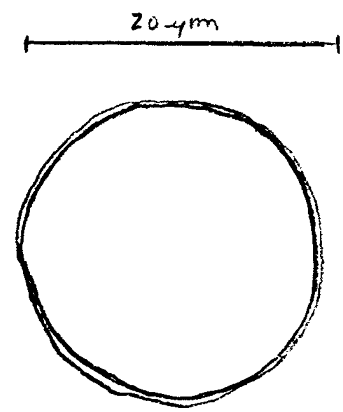


Fig. 5

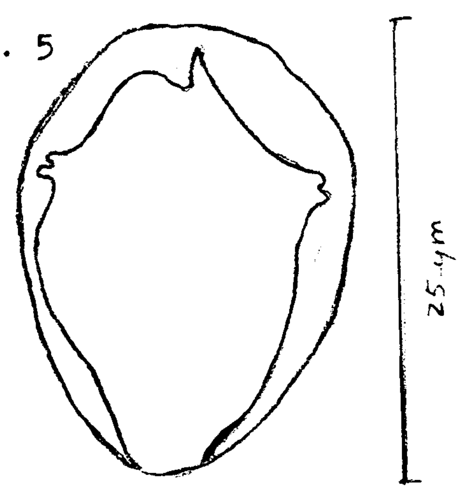


Fig. 6

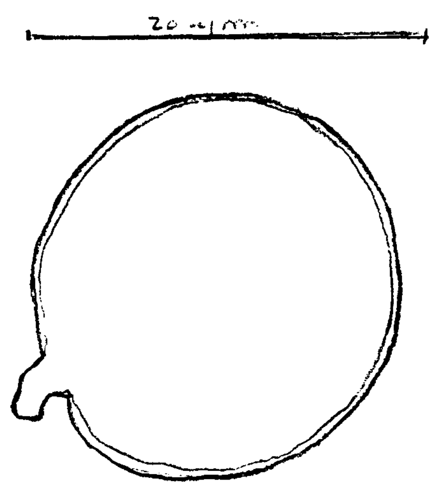


Fig. 7

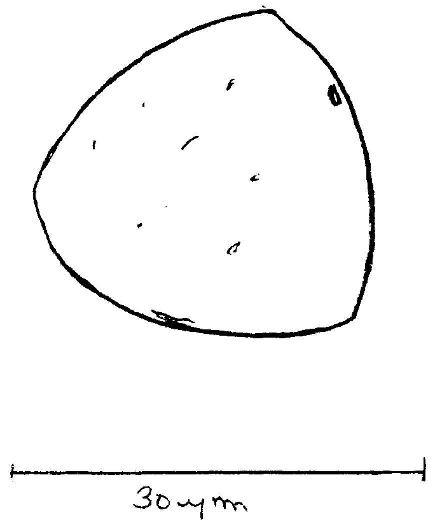


Fig. 8

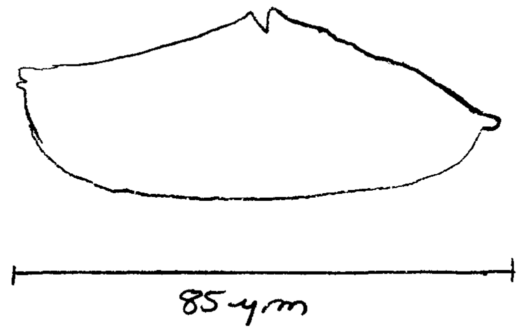


Fig. 9

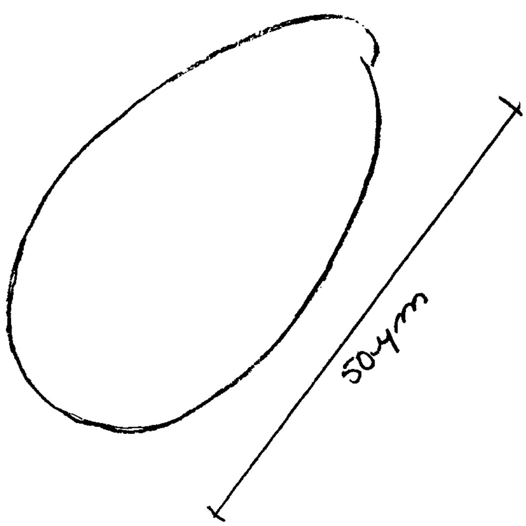
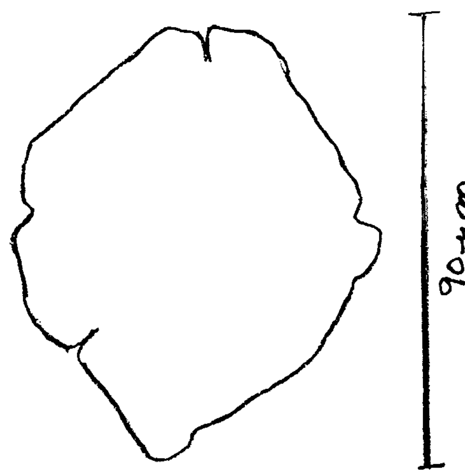


Fig. 10



Paleocene Shale

Locality: The second sample is an olive-gray shale of Paleocene age. It was taken from the Paskapoo Formation in central Alberta, Canada approximately fourteen km. east of Red Deer, Alberta. The rock unit from which the sample was collected consists largely of plant bearing strata. It is 7-10 mm. below a hard calcareous layer of sediment and 15-30 cm. above a sandstone unit. Plant remains are also present in both overlying and underlying sediments (Stockey and Crane, 1983).

Laboratory Observations: The shale reacted strongly to HCl acid, with HF acid it reacted violently. After maceration with HCl and HF acid, more than 50% of the original sample had dissolved. The bromide flotation did not cause the sample to separate into heavier and lighter parts, so the entire sample was saved. During the maceration procedure, the shale aggregated into clumps making it difficult to treat uniformily. After the material was mounted on slides, the slides appeared blank. Since the shale was in xylene solution, it was necessary to concentrate the sediment on filter paper, drawing the xylene through with a mild suction. The sediment that was collected on the filter paper was scraped onto a slide and mounted in HSR. The result was an adequate assemblege of palynomorphs on only a few slides.

Descriptions of Palynomorphs:

Type 1 (Fig. 1 and 2) Resembles Araucariacites australis (Couper, 1958).

In a count of 25 grains, this type came up eleven times. These grains are from 30-73 um and psilate to faintly reticulate. All grains have an irregularly shaped amb, but are approximately egg-shaped. The surface of the grains is covered with large wrinkles or folds in no particular pattern or distribution. This suggests the wall is relatively thin. Most grains have an obvious pore at one end.

Type 2 (Fig. 3) Similar to Inaperturopollenites magnus (Oltz, 1969).

Four out of 25 grains were of this type. They are approximately bean shaped (20 x 40 um), although the outline of these grains is irregular. The ornamentation is psilate and the surface is covered by large, thick folds or wrinkles in no particular orientation. There are no apparent apertures.

Type 3 (Fig. 4) Affinities unknown.

In the 25 grains that were counted, there was only one of this type. It is bean shaped (40 x 60 um) and has a protuberance at one end. The ornamentation is psilate and the surface is covered by large parallel wrinkles or folds that are aligned along the short axis of the grain.

Type 4 (Fig. 5 and 6) Resembles *Intertriletes scroiculatus* (Norton and Hall, 1969).

These grains were fairly common. Three were found in the 25 observed. They are subtriangular and have a long and short axis (35 x 42 um). Ornamentation is psilate. They have a thick but faint trilete mark with long laesurae.

Type 5 (Fig. 7) Similar to *Styx minor* (Norton and Hall, 1969).

One out of the 25 grains counted was of this type. It is 40 um with a circular amb. The ornamentation is difficult to distinguish because the grain is so dark; perhaps it is psilate. The wall looks like it is of two parts. In the center of the grain, the wall is dark. Toward the margin, the dark areas split and alternate with lighter areas. There are three furrows equally spaced along the amb.

Type 6 (Fig. 8) Resembles *Tricolpites bothyreticulatus* (Norton and Hall, 1969).

One out of the 25 grains counted was of this type. The amb is almost circular except for the neck-like process at one end. The grain is 30 um. The surface has a prominent reticulate pattern. The walls stand in relief about 1 um, and the lacunae resemble polygons. In the lacunae is a faint reticulate ornamentation. The neck-like structure looks like the site of an aperture.

Type 7 (Fig. 9) Resembles Tricolporopollenites (Doyle and Robbins, 1977).

Two out of the 25 grains counted were of this type. These grains are subtriangular and convex. They are 30 um and ornamentation is psilate. There are three pores or furrows, equally spaced along the amb, and around these apertures the wall becomes thicker.

Type 8 (Fig. 10) Similar to proximal side of Deltoidospora diaphana (Wilson and Webster, 1945).

Two out of the 25 grains counted were of this type. They are triangular concave and from 20-40 um. The ornamentation is slight. The grains are only slightly stained and some look partially degraded.

Type 9 (Fig. 11) Affinities unknown.

Only two out of 25 grains of this type were found. They are elliptical (40 x 100 um). Parallel folds are oriented along the long axis of the grain. One end has a tube-like protuberance which looks like a possible germination site.

Type 10 (Fig. 12) Affinities unknown.

Two out of 25 grains were of this type. They are diamond shaped and 24 um in size. In this view (Fig.12) there seems to be three equatorial bulges and two prominent poles. One pole has a disk shaped structure surrounding an obvious pore. Unlike the other palynomorphs, these grains look three dimensional.

Fig.1

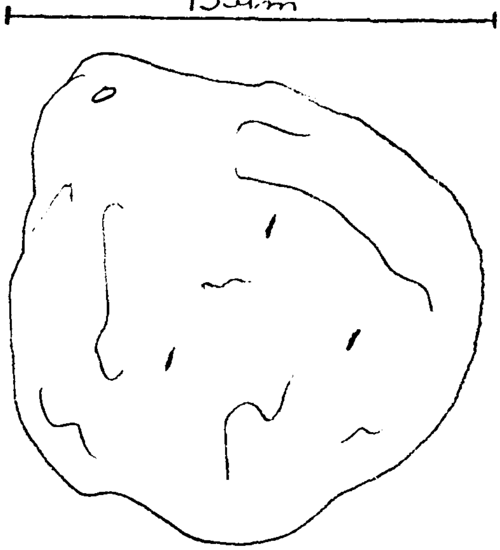


Fig.2

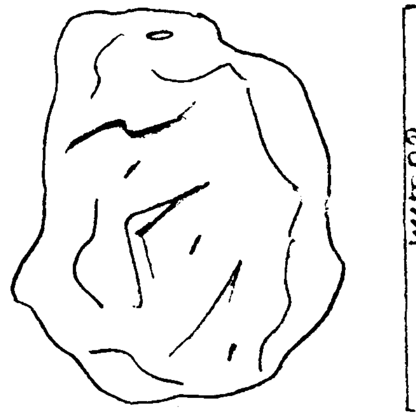


Fig. 3

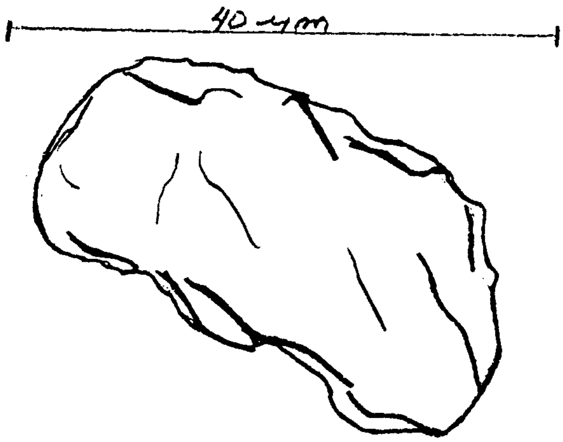


Fig. 4

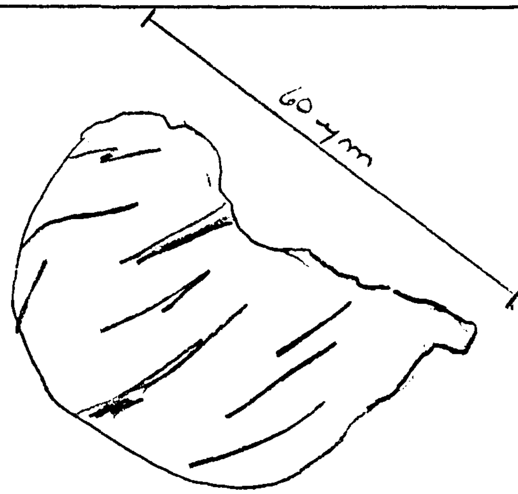


Fig. 5

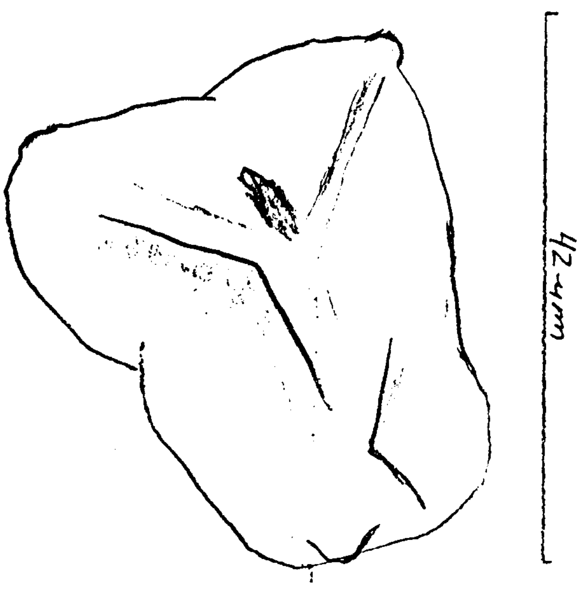


Fig. 6

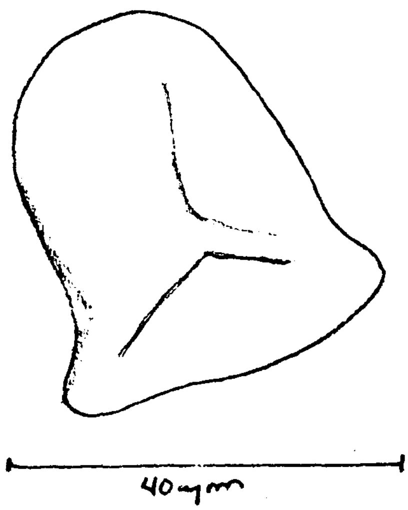


Fig. 7

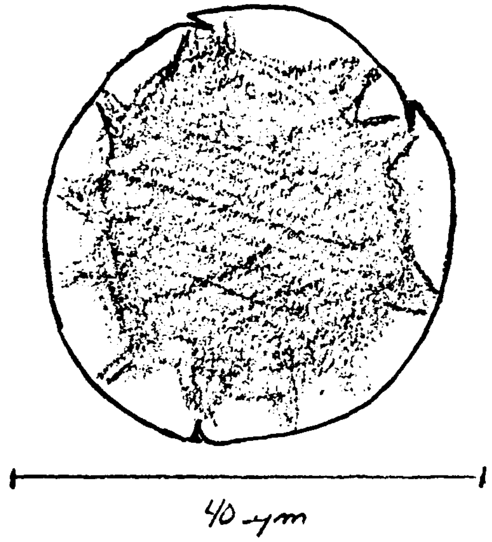


Fig. 8

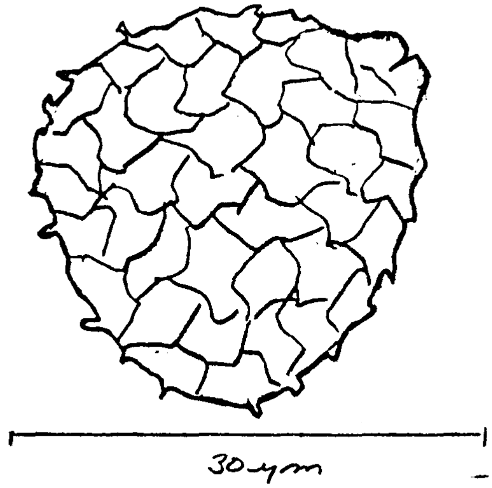


Fig. 9

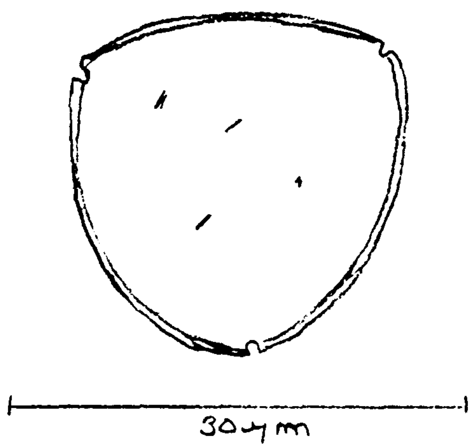


Fig. 10

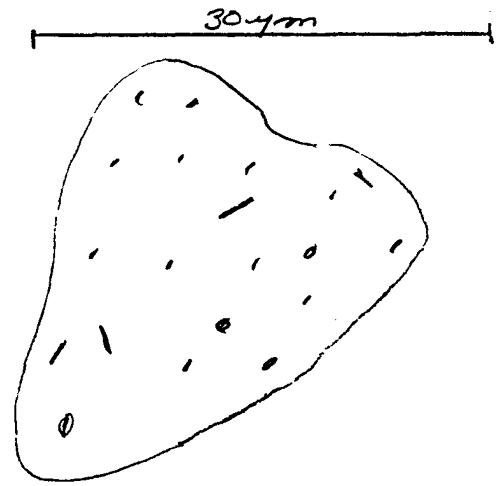


Fig. 11

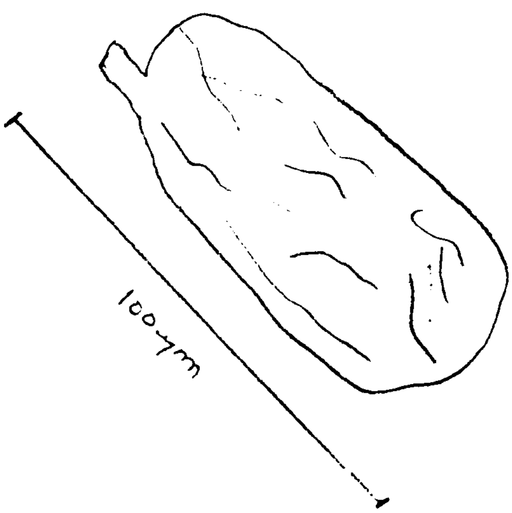
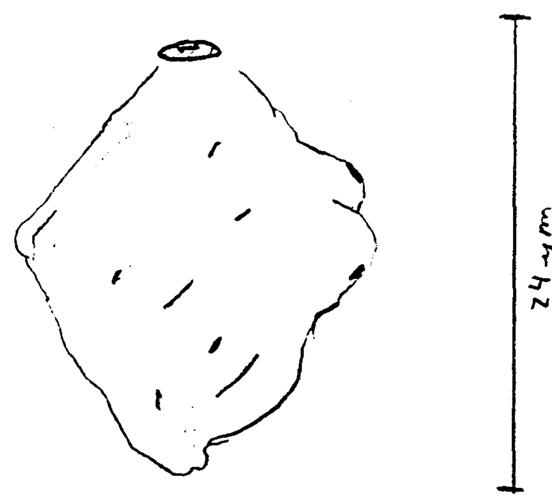


Fig. 12



Eocene Clay

Locality: The third sample is a light brown-orange Eocene clay, collected from western Tennessee. The clays in this region are generally found in the Middle Eocene Claiborne Formation and exist as isolated lenses underlain by sands and overlain by the present vegetation. They are well known for their abundance of plant remains, in particular leaf impressions (Dilcher, 1973). Judging by the elongate shapes of these deposits, as well as the underlying crossbedding, it is believed that the clays are mainly channel deposits or ancient oxbow lakes associated with low velocity streams (Dilcher, 1973).

Laboratory Observations: The clay reacted mildly with HCl acid. In HF acid, it reacted violently. As with the shale sample, Schulze's solution was not used. Unlike the shale, however; this sediment was very easy to work with and to mount on slides. Of the three samples, this one had the largest diversity and quantity of palynomorphs.

Descriptions of Palynomorphs:

Type 1 (Fig. 1 and 2) Affinity unknown.

Two out of 80 grains that were counted were of this type. These are elliptical grains 18-25 um. The ornamentation is psilate to faintly reticulate. There are two furrows, one at each end of the long axis of the grain and oriented parallel to the short axis. Fig. 1 and Fig. 2 are two orientations of the same kind of grain.

Type 2 (Fig. 3) Similar to Stellatopollis braghoornii (Doyle, Van Campo, and Lugardon, 1975).

Six out of 80 grains were of this type. These are elliptical grains about 10 x 15 um. The ornamentation is verrucate. One long furrow exists parallel to the long axis of the grain, and takes up less than 25% of one face.

Type 3 (Fig. 4) Similar to Castanea pumilia (Elsik and Dilcher, 1974).

Five out of 80 grains were of this type. These are elliptical and 25 x 35 um. The ornamentation is psilate. There are three colporate apertures parallel to the long axis of the grain.

Type 4 (Fig. 5) Resembles Lavigatosporites anomalus (Norton and Hall, 1969).

Fifteen out of 80 grains were of this type. These are elliptical and 5 x 10 um. The ornamentation is psilate. Some grains show a large furrow, parallel to the long axis, and which takes up over 50% of one face. Other grains have a faint lineation on one face, parallel to the long axis.

Type 5 (Fig. 6) Affinity unknown.

Ten out of 80 grains observed were of this type. These are elliptical grains in the 25 um size range. Positive relief structures are seen in some areas along the margins of the grains. Parts of the wall look tectate.

There are three colporate apertures parallel to the long axis of the grain.

Type 6 (Fig. 7) Similar to Neotriangulipollis (Médus, Boch, Parron, Lauverjat, and Triat, 1980).

These grains are triangular and in the 30-40 um range. The ornamentation is slight, but there are numerous pores on the surface of the grains. In addition to the pores, are three colpi which are equally spaced around the amb. Ten of these grains were found in the 80 that were counted.

Type 7 (Fig. 8) Similar to Papillopollis aradaensis (Kedves and Pittau, 1979).

Ten of the 80 grains that were counted were of this type. These grains are convex triangular and in the 30 um size range. The ornamentation is psilate to faintly reticulate. Three furrows are equally spaced around the amb. Also, just inside the grain margin and next to each furrow is a pore The three pores are associated with the three furrows.

Type 8 (Fig. 9) Resembles Calamospora (Good and Talyor, 1975).

These grains are 25 um and have a circular amb except for the tiny notch at one end. They are psilate and most grains have a few folds on the surface, as well as numerous pores. Many grains have a trilete mark with short laesurae Only five out of 80 grains were observed.

Type 9 (Fig. 10) Resembles *Retitricolpites geranioides* (Doyle and Robbins, 1977).

These grains are 25 um and resemble the bisaccate pollen grains of pines. The ornamentation is clavate, with conspicuous elements standing in relief about 1 um. There are no apparent apertures.

Type 10 (Fig. 11) Affinities unknown.

Three out of 80 grains were of this type. These have a subtriangular amb and are 25 um. One side has clavate-like elements and the opposite side looks psilate. Also, there are parallel striations on the grain surface. A furrow-like structure exists between two of the striae at one end of the grain.

Type 11 (Fig. 12) Similar to *Sequoia lapillipites* (Webster and wilson, 1945).

These grains are 20 um and have a circular amb, except for one bud-like structure. This protuberance could be the site of an aperture. The ornamentation is psilate to faintly reticulate. Four out of 80 were of this type.

Type 12 (Fig. 13) Resembles the proximal side of *Deltoidospora diaphana* (Wilson and Webster, 1945).

These triangular grains are 40-63 um. The ornamentation is psilate. A few folds and many pores cover the surface of these grains. Eight out of 80 were of this type.

Type 13 (Fig. 14) Resembles _Laevigatosporites_ (Norton and Hall, 1969).

Three out of 80 grains were of this type. These egg-shaped grains are 25 um. The surface has scattered pores and folds over it and it looks tectate.

Type 14 (Fig. 15) Similar to _Laevigatosporites_ (Brenner, 1963).

These bean-shaped grains are 25 um long. Many have a monolete-like mark as shown in Fig. 15. Three out of 80 were found.

Fig. 16 through Fig. 18 are line drawings of palynomorphs found in the Eocene clay but are not described here.

Fig. 1

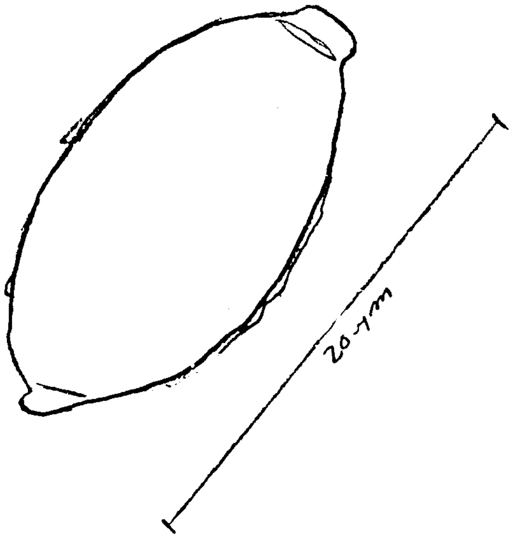


Fig. 2

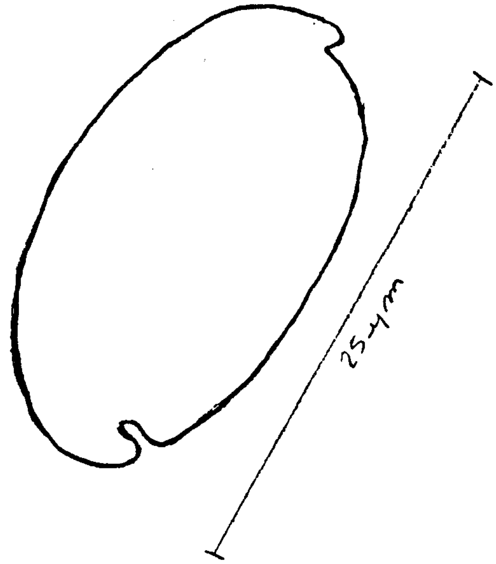


Fig. 3

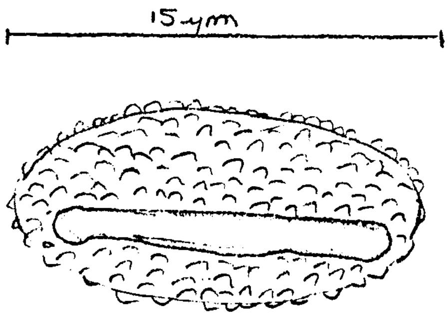


Fig. 4

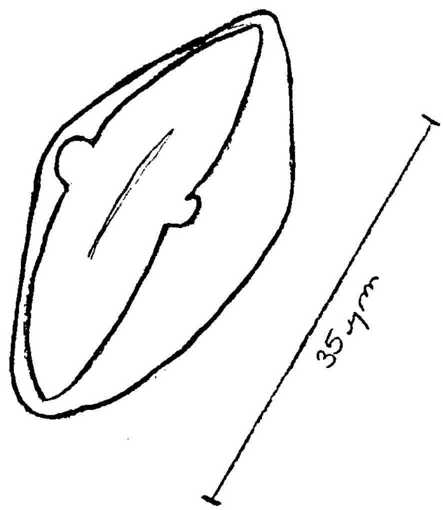


Fig. 5

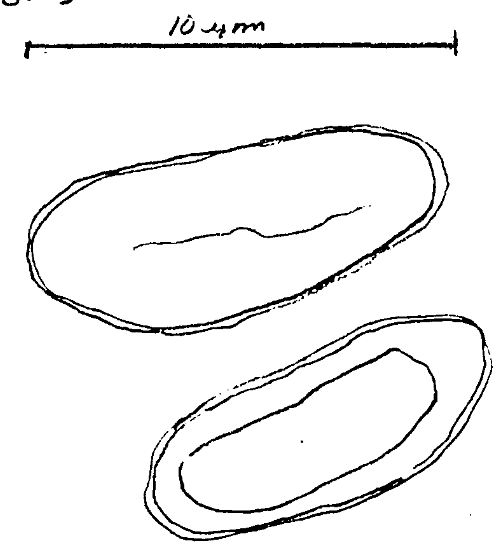


Fig. 6

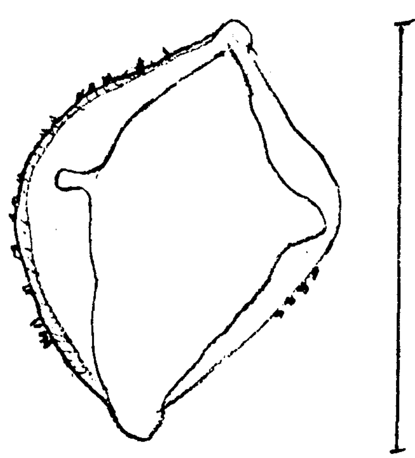


Fig. 7

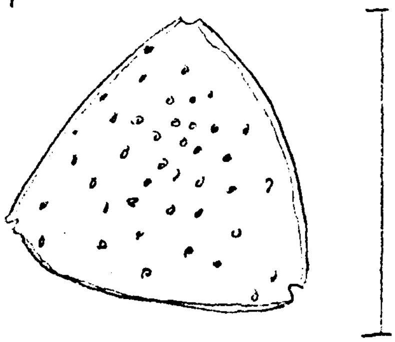


Fig. 8

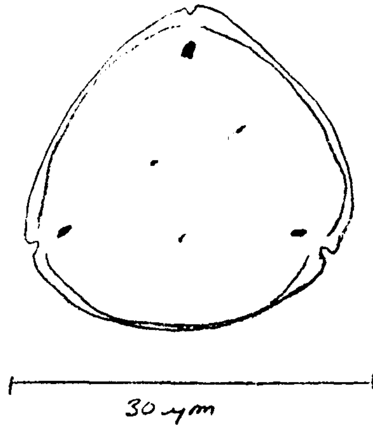


Fig. 9

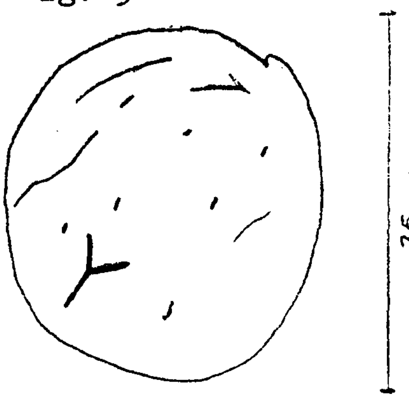


Fig. 10

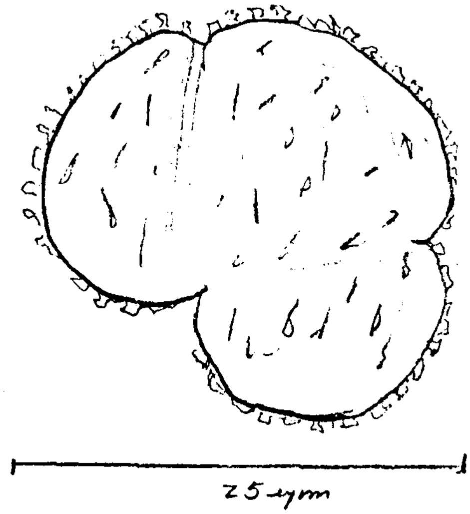


Fig. 11

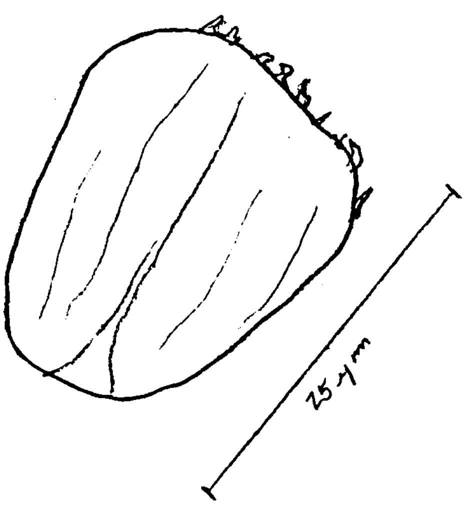


Fig. 12

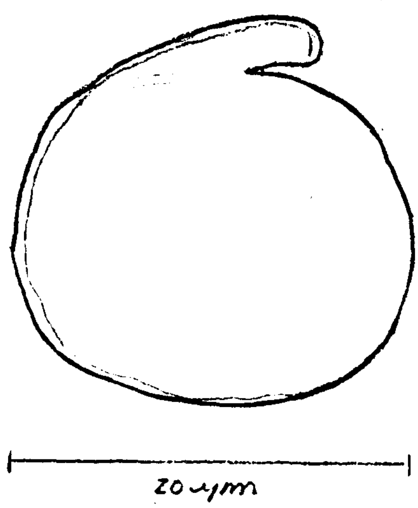


Fig.13

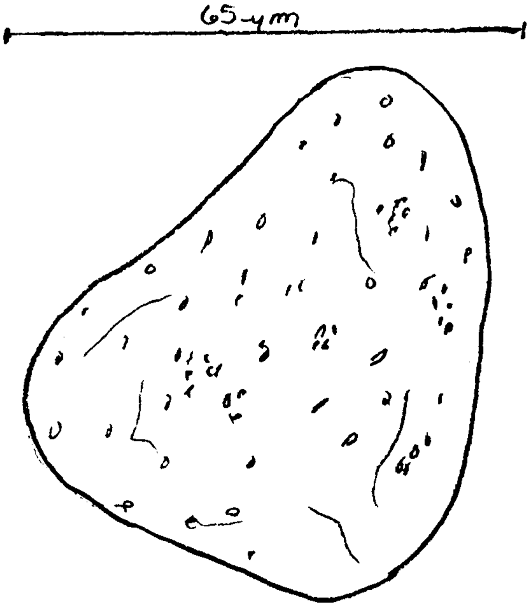


Fig. 14

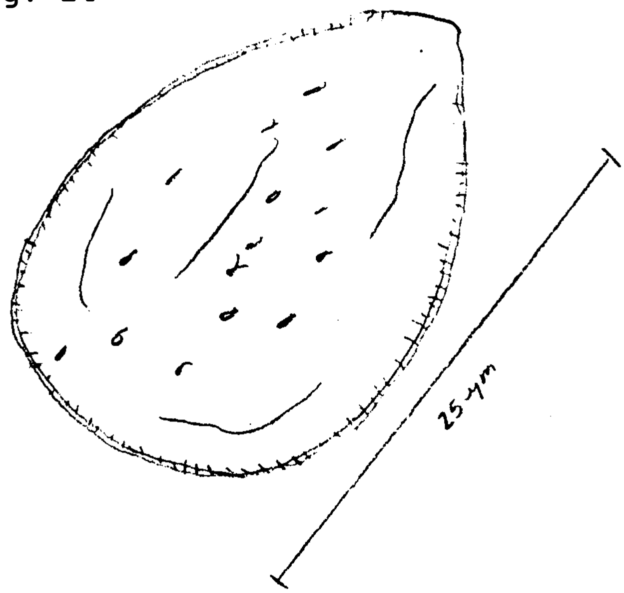


Fig. 15

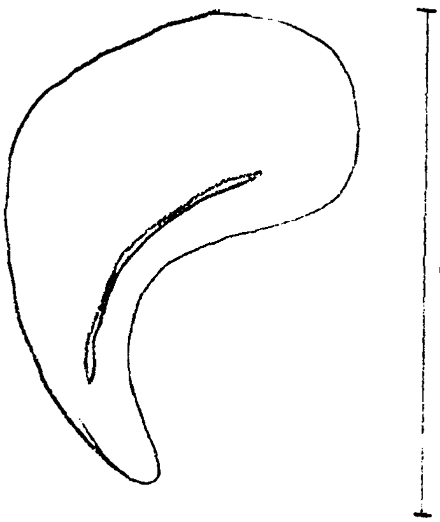


Fig. 16

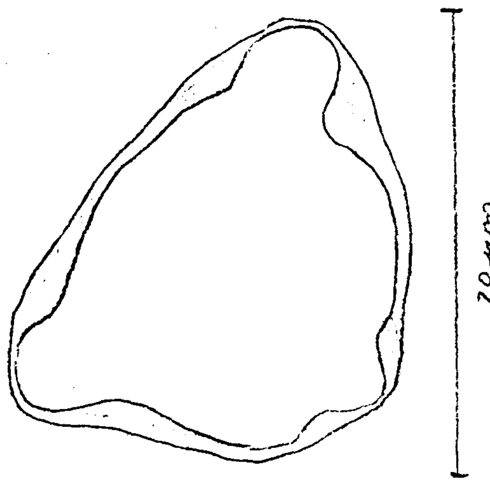


Fig. 17

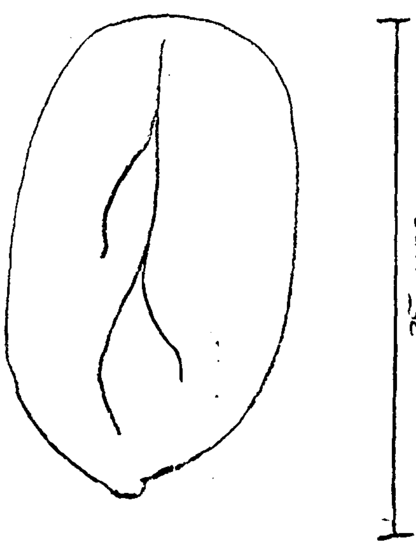
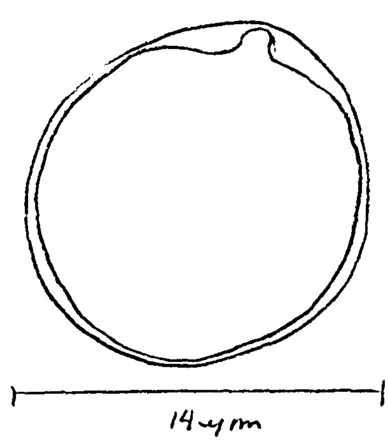


Fig. 18



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